

BMPs For Sale! – Implications from a Case Study in BMP Auctions

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Abstract. Over the past several decades, there has been an increase in the use of market-based approaches for environmental policy. The purpose of this paper is three-fold: 1) to provide a review of the literature on auction-based approaches to environmental management, 2) to gain insight into the use and effectiveness of an alternative auction designs, and 3) to present considerations for enhancing the use of flexible auction approaches for future environmental application. Specifically, this paper describes how innovative BMP auctions were used to distribute conservation funding in a small watershed in east-central Kansas and offers insights into their overall cost-effectiveness. Overall, there were 61 bids for practices requesting a total of \$98,524 in funding. Through the bid evaluation process, 46 of the bids were actually funded, which resulted in an estimated 2,901 tonnes of annual soil erosion reduction. This came at a total cost of \$62,566. The lessons learned from the project can help guide future conservation programs seeking market-based solutions to bring about environmental benefits and researchers interested in analyzing the effectiveness of these mechanisms.

1. Introduction

Among the principal challenges in dealing with agricultural nonpoint source pollution is determining appropriate incentives and the best policy design to induce producers to adopt pollution prevention practices. Despite years of effort and the investment of millions of state and federal dollars in various environmental incentive programs, many producers still choose not to participate in traditional conservation programs and/or decide not to implement best management practices (BMPs) on their agricultural fields (Smith et al., 2007). Further, an agency's ability to effectively target investments for the greatest environmental improvements for dollars spent remains a vital yet difficult goal to even measure, much less fully achieve.

The growing interest in market-based environmental management stems partly from cost-effectiveness (Atkinson and Tietenberg, 1991) and partly from the practical success governments have

had in dealing with specific pollution problems such as sulfur dioxide (SO₂) air emissions (Stavins, 1998) via these programs. The SO₂ program, enabled by the 1990 Clean Air Act Amendments, created a formalized market institution whereby emissions were tied to well-defined, transferrable property rights. Such formalized markets have also been applied to water-borne pollutants from agriculture, with over 40 water quality trading (WQT) programs in place in the United States (Breetz et al., 2004). Unlike the SO₂ market, however, WQT markets have suffered from low trading volumes, and many programs have yielded no transactions at all. Transaction data from these markets are virtually nonexistent. Hoag and Hughes-Popp (1997), Woodward and Kaiser (2002), and Peterson and Smith (2012) provided overviews of WQT initiatives and discussed a number of possible complications limiting participation.

Despite the lack of past successes of market-based approaches for water quality, interest remains

high. As mentioned previously, WQT is frequently mentioned, investigated, and implemented as a policy alternative in a variety of watersheds across the globe. In addition to WQT, more general market-based approaches also are supported and promoted by several U.S. agencies including the largest agricultural conservation agency, the Natural Resources Conservation Service (NRCS) (Knight, 2005). For example, the 2011 request for proposals for the NRCS-supported Conservation Innovation Grants (CIG) explicitly encourages and promotes the use of "market-based systems" (NRCS, 2011).¹ Seemingly, there is evident demand for more testing and analysis of market-based approaches for environmental management.

This paper describes a pilot project in which an innovative market-based approach was used to distribute conservation funding with the objectives of 1) encouraging producer/landowner conservation participation by offering greater flexibility to implement self-selected BMPs and 2) targeting funds in a cost-effective manner. The study area was the Pomona Lake watershed in eastern Kansas. In this project, BMP reverse auctions were used to help guide distribution of incentive funding. The purpose of this paper is three-fold: 1) to provide a review of the literature on auction-based approaches to environmental management, 2) to gain insight into the use and effectiveness of an innovative policy tool, and 3) to present considerations for enhancing the use of flexible auction approaches for future environmental application.

This paper begins with a review of relevant literature related to the empirics of market-based conservation for water quality. The next section provides a description of the methods used for conducting a BMP auction in a small eastern Kansas watershed. Following this section is a discussion of the auction results along with some insights into the relative cost-effectiveness properties of the auction. The paper concludes with thoughts and considerations for enhancing the use of BMP auctions in the future.

2. Literature review

The United States Department of Agriculture's (USDA) Economic Research Service (ERS) compared six hypothetical working-land conservation payment programs based on a fixed budget constraint

(Cattaneo et al., 2005). The hypothetical programs contained variations of design features: whether previous conservation efforts are rewarded or required for participation, whether incentives are based on practices or on performance, and whether producers are screened according to the relative benefits and costs of their working land payment program's contract. According to the researchers, a performance-based program with bid-down provisions (similar to the BMP auction) could improve environmental performance (as measured by the Aggregate Environmental Index) by more than 15 percent over current production patterns at the national level and by more than 17 percent in the Northern Plains region. The researchers estimated that a performance-based bid program could be nearly 12 times more cost-effective as a "good-actor payments" program (which makes payments based on past implementation of conservation practices).² The researchers concluded that a performance-based bid program could produce more environmental gain per dollar of program expenditure when compared to any of the other five programs analyzed.

The USDA ERS published a series of economic briefs related to conservation program design (Hansen and Hellerstein, 2006; Johansson, 2006; Weinberg and Claassen, 2006). In these papers, the authors pointed out how targeting farms and fields where conservation efforts are likely to generate the most profound or widespread environmental benefits was one way to achieve conservation goals. They assert that in most cases effective targeting must rely on quality data, biophysical and economic models, and the opinions of local personnel. The authors stated that in order to spend program dollars cost-effectively, conservation program managers also must motivate farmers to participate, then select those applicants who offer the greatest environmental gain per dollar spent. Bidding is one way to do that. When the cost to enroll all interested farmers exceeds available funding, bidding allows program managers to select the best applicants by comparing contract offers based on environmental benefits to costs.

In 2007, the Soil and Water Conservation Society (SWCS) and Environmental Defense published a series of reports focusing on major USDA conservation programs. The intent of the assessments was to provide a better understanding of how well these

¹ This has actually been the case many times over the past decade, not just in the 2011 request for proposals.

² For example, under the Conservation Security Program (CSP), producers may qualify for payments based on practices that were adopted or installed before enrollment.

programs were achieving conservation objectives and how they might be improved (SWCS, 2007a; SWCS, 2007b). The authors evaluated the cost-effectiveness of Environmental Quality Incentives Program (EQIP) applications by comparing the anticipated environmental benefits to the cost of the anticipated contract. The importance of evaluating cost-effectiveness was recognized both in the 2002 Farm Bill and in the EQIP program implementation guidelines. The report stated that the consideration of cost-effectiveness in the selection of BMPs not only improved program performance but also addressed issues of equity by creating a level playing field for small and large producers.

According to assessments conducted by Environmental Defense in 2003 and 2004, NRCS has had a poor track record of incorporating cost-effectiveness into the conservation funding decision-making process (Searchinger and Friedman, 2003; Friedman and Heimlich, 2004). The researchers indicated that the most effective means of evaluating cost-effectiveness in EQIP applications was to create a ratio by dividing an application's total environmental points (e.g., soil erosion reduction, nutrient reduction, etc.) by its estimated total costs to select from among the pool of EQIP applications. Our pilot project attempted to do something similar.

Two BMP reverse auctions used in the Conestoga Watershed in Lancaster County, Pennsylvania, allowed producers to submit bids for the installation of BMPs (Greenhalgh et al., 2007). Some of the BMPs submitted included contour strip cropping, grassed waterways, waste storage facilities, and terraces. Overall, the \$486,000 allocated to agricultural producers resulted in 92,000 pounds of phosphorous reduction. This translated to an average cost-effectiveness of \$5.28 per pound of phosphorous reduction and an overall 8.4 percent reduction in annual phosphorous loading in the Conestoga watershed (Susquehanna River Basin Commission, 2005).

Reverse auctions also have been piloted in the NRCS Wetlands Reserve Program (WRP). According to the Chief of NRCS, 1,417 hectares of wetlands were enrolled into the WRP through the reverse auction pilot program at an acquisition costs savings of nearly \$820,000, or 14 percent (NRCS, 2006).

Selman et al. (2008) further examined the cost-effectiveness of the reverse auction used in the Conestoga watershed by comparing the results of the auction to traditional EQIP. Specifically, the authors examined the contracts funded through EQIP in December 2005 and those funded through the

Conestoga Reverse Auction in February 2006. In total, EQIP received 19 applications for the December 2005 enrollment period and 13 of these were funded. Phosphorus reductions were calculated using NutrientNet, which was the same program used to calculate the reductions in the reverse auction.³ The results showed that EQIP-funded projects were expected to reduce 10,520 pounds of phosphorous over the life of the projects at a cost of \$275,552.

To compare the EQIP allocations to the reverse auction, a virtual budget constraint of \$293,000 was used for the February 2006 auction to make for a more valid comparison to the EQIP allocations (the actual February 2006 auction costs were \$446,990). Imposing this constraint, the first 7 reverse auction contracts were compared to the 13 EQIP contracts. The authors found that the 13 practices funded through traditional EQIP resulted in a cost-effectiveness of $\$275,552/10,520 = \26.19 per pound. On the other hand, the 7 practices funded by the reverse auction came at a cost of \$292,635 with 80,787 pounds of phosphorus reduction yielding a \$3.62 per pound cost-effectiveness value. Thus, the reverse auction was approximately 7 times more cost-effective than the traditional EQIP approach.

While there were many similarities between the two sets of observations (e.g., similar types of BMPs were funded), there were some notable differences. The auction ranked bids based on a single environmental outcome, whereas the EQIP contracts were ranked according to several resource concerns, not just water quality. So, the EQIP-funded practices may have outperformed the auction in regards to other environmental, resource, and/or wildlife elements.

Because the auction did not limit bid prices, it seemed to attract farmers who would not participate in traditional EQIP because of financial constraints.⁴ In one instance, a farmer who bid the entire cost of a manure management system was funded by the auction because of the significant reductions in phosphorous achieved by this BMP. This particular project, which was one of the most cost-effective of the entire auction, would not have been funded through traditional EQIP.

³ Available at www.nutrientnet.org, NutrientNet was developed by the World Resources Institute and is a suite of web-based tools used to facilitate market-based approaches to improving water quality.

⁴ In EQIP, contract payments are based on fixed-rate payments for certain practices and cover no more than 75 percent of total project costs. The reverse auction did not limit participants to bidding the standard cost-share payment rates.

Connor et al. (2008) examined the cost-effectiveness of the Catchment Care Australian conservation auction. The Catchment Care was a sealed bid, first price, discriminant price auction where landowners submitted bids to a watershed management board proposing a suite of conservation actions and a price. Bids were evaluated based on price and an environmental benefits index (EBI) score. The cost-effectiveness of bids was calculated by dividing the EBI by the bid price. The bids were ranked and selected for funding in order of cost-effectiveness until the available funds were exhausted. The auction outcome was then compared to estimated outcomes of two alternative payment policies: a) a uniform payment and b) a 'ranked' uniform payment policy with selection of projects based on EBI/\$.⁵

In comparison to the auction approach, the uniform payment method resulted in 56 percent of the environmental benefits of the auction with the same level of overall expenditure. The level of environmental benefits varied widely, ranging from about 17 percent to 98 percent of the environmental benefits resulting from the auction. Alternatively, in order for the uniform policy to achieve the same level of environmental benefits a 150 percent increase in costs would be necessary. The finding that a uniform payment scheme was about half as cost-effective as the auction was consistent with the previous studies of Stoneham et al. (2003) and White and Burton (2005).

3. Methods

Pomona Lake reservoir is located approximately 30 miles (48 kilometers) south of Topeka, Kansas. The watershed (Figure 1) includes portions of Lyon, Osage, and Wabaunsee counties. With a total watershed area of about 83,657 hectares (323 sq. mi.), Pomona Lake was constructed in 1963 and reached full pool in 1965. The authorized purposes of the project include flood damage reduction, recreation, water quality improvement, and fish and wildlife management. The main water quality threats to Pomona Lake are sedimentation, nutrients, and bacterial contamination. The lake is among those listed on the state's 303(d) list for water quality impairment due to eutrophication and silt (Kansas Department of Health and Environment, 2001).

The state of Kansas uses a watershed management planning framework that engages citizens and other stakeholders to join together in protecting and restoring Kansas water resources. Each application of this framework to a specific watershed is known as a Watershed Restoration and Protection Strategies (WRAPS) project. WRAPS projects are to be grass-roots, stakeholder-driven processes. These projects are supported through the Kansas Department of Health and Environment (KDHE) using funds from U.S. Environmental Protection Agency (EPA) Section 319 and the Kansas Water Plan.

Among the Pomona Lake WRAPS stakeholder leadership team's goals was to reduce the amount of sediment that enters Pomona Lake. The team agreed to direct BMP investments using an auction-based approach. The team insisted on a high degree of simplicity and flexibility in the BMP implementation criteria. In short, BMPs did not have to conform to strict guidelines and standards typical of USDA-funded BMP projects and participants could bid for practices not traditionally funded through other programs. The main purposes of keeping the auction simple and flexible were to enhance the attractiveness of the auction to farmers and landowners unfamiliar with market-based conservation and to appeal to those who had been resistant to participating in USDA conservation programs. It should be noted that the primary purpose of the BMP auction was not research, and it was understood that making a simple and flexible auction program (operating very differently from existing USDA conservation programs) could pose later challenges in comparing its cost-effectiveness to that of other programs.

Three BMP auctions were conducted in the watershed. The first auction was held during the summer of 2007, the second took place during the summer of 2008 (from this point forward, simply 2008A), and the third occurred during the winter months of 2008 (2008B). It should be noted that, at the time, producers were not aware of the potential for successive auctions. Furthermore, the results of previous auctions were not made readily available to producers.

Using a field sign-up sheet, producers had the option of identifying soil erosion reduction BMP(s) they were willing to use on a field. They could choose from the BMPs listed or write in their own BMP proposal to reduce soil erosion either on cropland or pasture/rangeland. Next, they indicated the amount of money they would need to install and maintain the BMP(s) selected (for a minimum of one season), understanding that bids would be

⁵ Connor et al. (2008) actually compared four payment policies, but only the two most relevant are discussed here.

ranked by cost-effectiveness. They could sign up multiple fields, but the total amount per producer/landowner could not exceed \$5,000. A maximum

limit was put in place simply to prevent the money from being concentrated on one or a few producers.

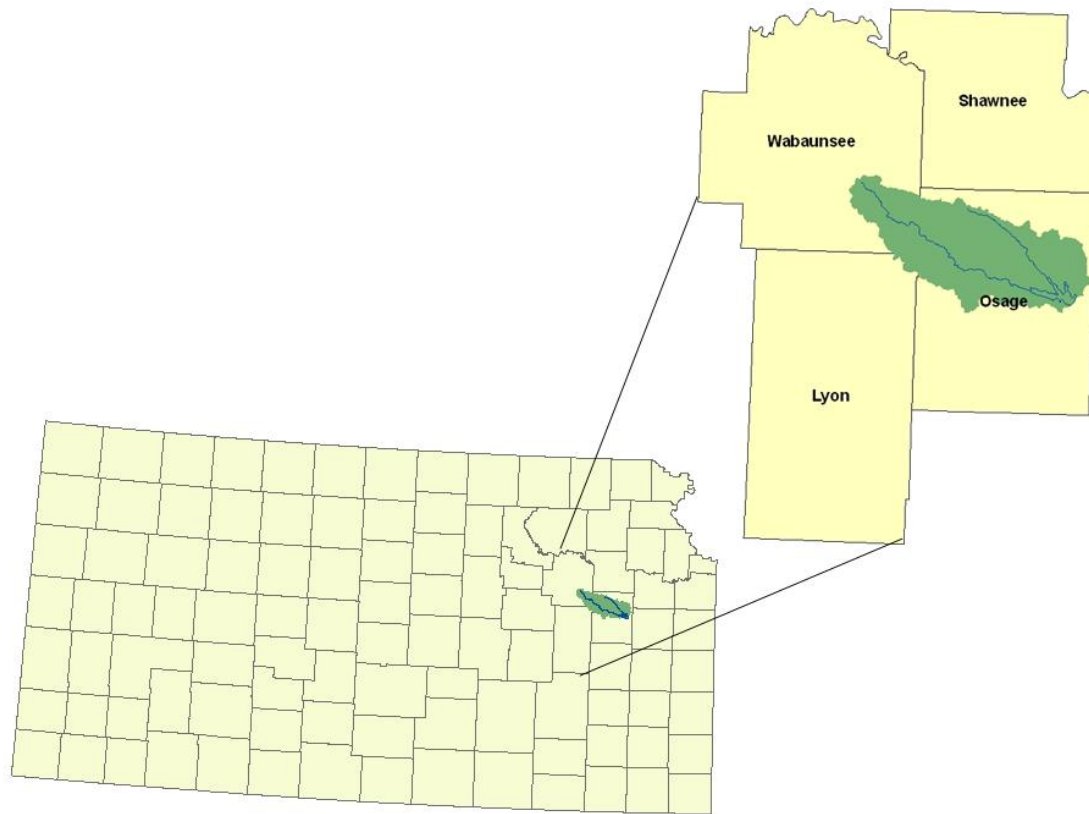


Figure 1. Pomona Lake watershed map.

The first objective of the Pomona BMP auction project was to estimate the amount of soil erosion reduction that would result from the adoption of the proposed agricultural BMPs. Given a producer's current cropping rotation, field legal description, and current use of agricultural BMPs, each bidder was assigned a baseline soil load (in tonnes per hectare) based on the Revised Universal Soil Loss Equation (RUSLE2) model (NRCS, 2004). When a producer submitted a BMP bid, the baseline load was multiplied by the estimated soil erosion reduction efficiency.⁶ The amount of erosion reduction was measured in tonnes per hectare. Guidance was available to producers during the bidding process

for help in determining costs and baseline erosion values.⁷

Producers were allowed to submit bids for the installation of up to three BMPs on the same field. The cumulative erosion reduction efficiency of multiple BMPs was derived from equation 1 (modified from the STEPL BMP Calculator) (STEPL, 2006):

$$BMP_e = 1 - \frac{\sum_{i=1}^n T_i (1-e_i)(1-e_{i+1}) \dots (1-e_n)}{\sum_{i=1}^n T_i} \quad (1)$$

where n is the number of BMPs, T_i are areas being protected by a given BMP, e_i is the pollutant removal efficiency of the i th BMP, and $(1-e_i)$ are pollutant-retaining efficiencies.

Since BMP order is important in calculating the overall BMP erosion reduction efficiency, this calculator ranks the individual BMPs in order from the

⁶ See Devlin et al. (2003) for the reduction efficiencies of accepted BMPs. In the case of new BMPs, the technical team (comprised of NRCS, Conservation District, and University Research and Extension personnel) estimated erosion reduction efficiencies employing a "consensus best guess."

⁷ The majority of producers, however, did not seek much assistance during the bid processes.

least to the greatest efficiency (e.g., the least efficient BMP is represented by e_1 and T_1 in equation (1)). This procedure benefits the producer insofar as it may overestimate the overall BMP reduction efficiency.⁸

The next step was determining the cost per tonne of erosion reduction. This was calculated by dividing the per hectare bid price by the soil erosion reduction (equation 2). The resulting value was expressed in dollars per tonne of erosion reduction.

$$Cost = \frac{Bid}{BSL * BMP_e} \quad (2)$$

where *Cost* is the cost per tonne of erosion reduction; *Bid* is the bid price submitted by the producer in dollars per protected hectare (e.g., if a 2 hectare vegetative buffer is treating runoff from 50 hectares of cropland, then the protected hectares are equal to 50 hectares); *BSL* is the baseline soil load derived from the RUSLE model in tonnes per hectare; and *BMP_e* is the soil erosion reduction efficiency of the BMP(s).

The last step in the bid evaluation process was ranking the bids. This was accomplished by simply ranking the bids from least to greatest, in terms of cost per tonne of soil erosion reduction. The producer who offered erosion reduction at the lowest price was contracted with first. An amount of \$20,000 was available for funding BMPs in 2007 and 2008A while \$27,525 was available for the 2008B auction.⁹

When evaluating the BMP auction approach compared to traditional conservation programs the first question is one of relative cost-effectiveness. That is, what would the cost per tonne of sediment reduction have been if traditional programs were utilized instead of the auction? Given the unique flexibility offered to producers in terms of BMP selection, it is impossible to compare the auction traditional programs directly. Hence, we calculated the costs and sediment reductions of applying "similar" BMP(s) to the same cropland fields (hypothetically) using traditional conservation funding. This allows us to offer preliminary comparisons between these two approaches.

4. Results and discussion

In the 2007 auction, 24 bids for practices requesting \$19,062 in funding were submitted. Because this was less than the allotted \$20,000 budget, all the bids were funded. The bids came from 13 landowners/producers. Almost half (11) of the practices were "stacked" on top of other traditional conservation program payments, which was allowed under the auction rules. The BMP projects were of various types: 5 vegetative buffer establishments, 4 re-shaping of terraces, 4 permanent vegetation establishments, 2 grass waterway establishments, 1 terrace establishment, and 8 projects falling into the "other" category.¹⁰

The initial baseline soil loss at the edge of the fields, as estimated from the RUSLE model, totaled 1,128 tonnes of soil across the 24 sites. Based on estimates and calculations, 851 tonnes of soil loss were reduced at the edge of the field for an overall erosion reduction efficiency of 75.4 percent. The 851 tonnes of soil loss reduction came at a cost of \$19,062 for an overall cost-effectiveness of \$22.40 per tonne. The lowest bid received in the 2007 auction was for establishing quail habitat at \$1.07 per tonne of soil erosion reduction while the highest bid received was for re-shaping existing terraces at \$2,205.00 per tonne of soil loss reduction. The variation in producer bid prices per tonne of erosion reduction is graphically depicted in Figure 2. A full description and ranking of all of the bids can be obtained from the authors upon request.

Examining Figure 2, one will notice the sharp increase in steepness of the marginal cost curve for the 2007 auction and may question why all bids were funded when there were some bids significantly greater than the rest. For this inaugural auction, the Pomona stakeholder leadership team chose not to decline these higher bids. In some instances, however, it may be logical to put a (reserve) bid (\$/tonne) ceiling and choose not to fund bids that exceed this limit. Determination of this bid ceiling could be based on historical averages from traditional conservation programs, by statistical methods (e.g., a given number of standard deviations away from an "Olympic" average), or a variety of other approaches.¹¹

⁸ This was a decision supported by the stakeholder leadership team in an effort to promote the implementation of multiple BMPs on the same field.

⁹ For additional information on how an auction can be designed and implemented in a watershed, interested readers are referred to Smith et al. (2009).

¹⁰ The "other" category includes BMPs such as: repairing creek bank, creating a diversion, establish quail habitat, reshape washed out area, build up waterway berm, and other BMPs not specifically listed on the bid sheet.

¹¹ An "Olympic" average is the average after removing the high and low values.

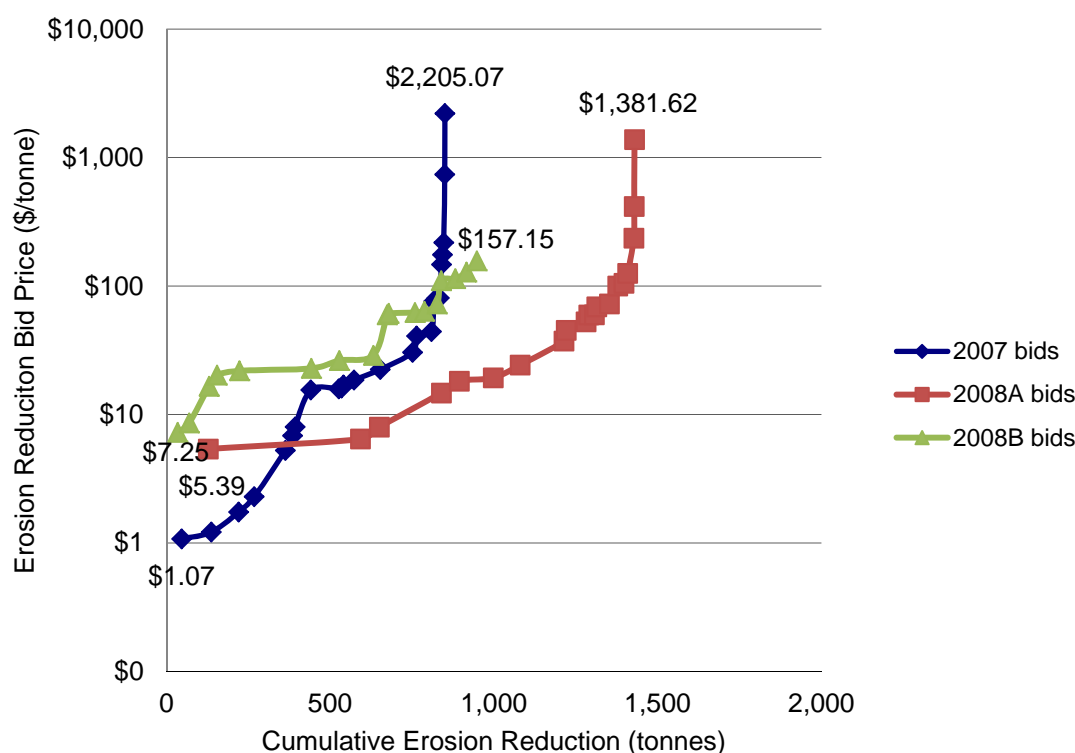


Figure 2. Variation in Pomona Watershed producer bid price for 2007 and 2008 auctions.

In the 2008A auction, 20 bids for practices requesting a total of \$37,508 in funding were submitted. Due to the \$20,000 funding limit, only the 9 most cost-effective bids were funded (at a total cost of \$17,250¹²) and the remaining 11 bids were rejected. The proposed BMP projects included: 8 terrace establishments, 6 re-shaping of terraces, 2 permanent vegetation establishments, 2 combinations of BMPs, 1 grass waterway establishment, and 1 project in the “other” category.

Just focusing on the 9 fields where BMPs were accepted, the initial annual baseline soil loss was 3,658 tonnes over 92 field hectares. The accepted BMPs were estimated to reduce 1,224 tonnes of soil erosion for an overall soil erosion reduction efficiency of 33.4 percent.¹³ The cost-effectiveness of the 2008A auction was \$17,250/1,224 tonnes = \$14.10

per tonne. The variation in cost-effectiveness for all of the bids received in 2008A can be seen in Figure 2. Note that this figure includes all bids received; some were not funded.

The 2008B auction resulted in 17 bids (4 re-shaping of terraces, 7 terrace establishments, and 6 “other”) for practices requesting nearly \$42,000 in funding. After the bids had been evaluated and ranked only 13 of the bids were funded. In regards to the 13 accepted bids, the fields had a total annual baseline soil loss of 1,364 tonnes. The implementation of BMPs was estimated to reduce soil loss by 826 tonnes for an overall reduction efficiency of 61 percent. This came at a cost of \$26,254 or \$31.78 per tonne. The variation in cost-effectiveness for all of the bids received in 2008B can be seen in Figure 2.

Altogether, the three auctions resulted in an estimated 2,901 tonnes of soil erosion reduction (see footnote 13). This came at a total cost of \$62,566 which translated into an average cost-effectiveness of \$21.57 per tonne.

As indicated, there were five bids for installing vegetative buffers. Only two of the five bids were independent of another conservation program. Three of the five bids were “stacked” on the Continuous Conservation Reserve Program (CCRP)

¹² The next “best” bid was for \$3,200 which would have exceeded the \$20,000 budget by \$450. The bidder was given the option of lowering their bid to \$2,750, but this offer was declined. The bidder indicated that they would most likely wait until a future auction. This seems to be more evidence that bidders are bidding at or close to their “true” costs.

¹³ This is the expected sediment reduction for the first year. After that, sediment reductions may increase or decrease depending on the amount of maintenance performed as well as other factors (e.g., as the type and density of vegetation changes).

cost-share and incentive payments for a 10-15 year period. The CCRP offers one-time cost share payments to cover 90 percent of the county average cost of installing a buffer. In addition, there is a sign-up incentive payment of \$247 per hectare.¹⁴ The CCRP also offers annual incentive and maintenance payments equal to 120 percent of the county cropland rental rate and \$9.88 per hectare per year for ten years, respectively. In Kansas, the overwhelming majority of producers utilize CCRP for vegetative buffer establishment versus other funding sources such as EQIP. Hence, CCRP is the most viable funding alternative for vegetative buffers and will be used for the cost-effectiveness comparison.

Using the KSU-Vegetative Buffer decision-making tool (Smith and Williams, 2007), we calculated the total present value of the CCRP payments for a one hectare vegetative buffer in Osage County, Kansas. Using a discount rate of 5 percent, the total present value of the CCRP payments over a ten year span was \$2,179 per hectare – this is the amount of money the program pays out over a ten year period measured in current dollars (e.g., 2012). Examining the two bids for buffers that were not “stacked” on top of the CCRP payments, we can analyze the cost differentials. The first vegetative buffer bid was for seeding 0.33 hectares to grass. The producer’s bid for this practice was a \$150.00 one-time payment. This was equal to a cost of \$455 per hectare for a vegetative buffer. Performing these same calculations for the second bidder, who bid \$800 for a 0.24 hectare buffer, the cost was equal to \$3,333 per hectare.

Considering these results, no clear conclusion can be drawn in terms of cost-effectiveness. The first bid was significantly below the \$2,179 average present value costs of the CCRP, while the second bid was about \$1,154 higher than the costs of the CCRP. The weighted average of the two is equal to \$1,667 per hectare which is \$512 less costly than average. This indicates that the Pomona auctions were slightly more cost-effective for vegetative buffers than traditional conservation funding programs (assuming identical baseline soil losses and reduction efficiencies).

One caveat to this preliminary conclusion is that the producers who installed vegetative buffers through the BMP auction were not required to

follow the same guidelines and regulations as those who installed buffers through a program such as the CCRP. For example, there was no set timeline for how long the producer/landowner must leave their auction-funded buffer in place. Though unlikely to occur, the producer could plow it after the first year with no penalty. Nevertheless, it is important to consider other factors besides simply cost per tonne of sediment reduction.

The other three bids for vegetative buffers were “stacked” on top of the CCRP payments and fall into a different category. If we neglect the CCRP payments, however, the per-hectare costs for vegetative buffers were equal to one-time costs of \$642, \$82, and \$158 per hectare. The question here is whether these producers/landowners would have installed these buffers without the added incentive available from the BMP auction. Unfortunately, we do not have that information.

There were a total of six bids for establishing permanent vegetation on a cropland field. All six of these bids were for fields in continuous soybean rotations. A total of 28.6 hectares of cropland were bid to be converted to permanent vegetation (bidders were not required to indicate the type of vegetation). The 28.6 hectares came at a total bid price of \$8,050; yielding a per-unit cost of \$281 per hectare. The general sign-up conservation reserve program (CRP) funds the establishment of permanent vegetation on entire fields and is widely used, so it seems most reasonable to make cost-effectiveness comparisons to this traditional program. The CRP operates similarly to the CCRP except with slightly lower incentives and a competitive sign-up process. As before, using the KSU-Vegetative Buffer decision-making tool (Smith and Williams, 2007), we calculated the total present value of CRP payments on a per hectare basis for land in Osage County, Kansas. The total present value of CRP payments over a ten-year span was \$1,507 per hectare (2007 dollars). So, the cropland converted to permanent vegetation through the BMP auction came at an 81 percent cost-savings over the CRP (assuming identical baseline soil losses and reduction efficiencies). Again, as with the vegetative buffers, there were not many restrictions or guidelines (as there are with the CRP) placed on the producers/landowners who bid for this practice. They are allowed to establish whatever type of permanent vegetation they desire (e.g., warm or cool season grasses, legumes, etc.) and to hay and/or graze the vegetation if they desire; so, although not directly comparable to CRP, the BMP

¹⁴ The majority of landowners installing vegetative buffers utilize the CCRP due to relatively higher levels of cost-share and incentive payments compared to EQIP. Thus, comparisons are made to CCRP and not EQIP.

does address a common complaint concerning too many restrictions.

Several of the bids came for practices that are not currently funded under existing conservation programs. An example would be “re-shaping existing terraces.” There were 18 bids for re-shaping existing terraces. The 18 producers/landowners requested a total of \$14,900 for re-shaping terraces on 55.5 hectares of cropland. The RUSLE model estimated that the 55.5 hectares of cropland lost 465.0 tonnes of soil annually to erosion. Assuming that re-shaping of terraces is 25 percent effective at reducing soil erosion, 116.3 tonnes of soil would be saved annually for an average cost-effectiveness of \$128 per tonne of soil. Since re-shaping of terraces is not funded under existing conservation programs, we will compare this to a similar (but traditionally-funded) BMP such as terrace establishment.

In 2007, EQIP would pay a 50 percent cost-share for terrace establishment based on a state average cost of \$4.99 per meter. Communication with the Osage County Conservation District revealed that nearly all producers and landowners utilize state of Kansas Soil Conservation Commission (SCC) funds, which pay a 70 percent cost-share rate, for terrace establishment. For this reason, a 70 percent rate was used to estimate a one-time cost-share of \$3.49 per meter. To make relevant comparisons, the cost needs to be converted to a cost per protected cropland hectare. According to Kling et al. (2007), the high and low estimates for the number of meters of terrace required to protect 1 hectare of cropland were 132.7 meters per protected hectare and 50.8 meters per protected hectare, respectively.¹⁵ Using an average of 91.8 meters per protected hectare, the average cost per protected hectare was \$320.66. If terraces were established via SCC funds to the same 55.5 hectares of cropland, 232.5 tonnes of soil erosion would be prevented (assuming 50 percent erosion reduction efficiency) at a total cost of \$17,796. Simply dividing the total cost by the annual soil erosion reduction, the average cost-effectiveness of the CRP on these fields would be equal to \$77 per tonne of soil. Therefore, in this sample, re-shaping terraces through the BMP auction resulted in higher sediment reduction costs compared to establishing new terraces through the SCC. However, as the existing terraces continue to break down and erode, the auc-

tion approach may become more cost-effective. For example, if we were to assume that re-shaping terraces would have an erosion reduction efficiency of 42 percent, re-shaping terraces becomes more cost-effective than establishing new terraces on similar fields (assuming the total costs remain the same).¹⁶

5. Conclusion

There are several benefits to coupling an auction approach with flexible BMP implementation funding. In the marketplace, where numerous producers are providing such information, project sponsors can select among competing bids to purchase the most cost-effective bundle of pollution-reduction investments. Further, the information provides valuable insights into the incentive levels required to induce producers to adopt various desirable practices, which is a key piece of information lacking from other studies (e.g., Ortega-Pacheco et al., 2009).

This paper provided a brief review of the conservation auction literature followed by detailed examples of implementing BMP auctions in the Pomona Lake Watershed in Kansas. While the bid data generated from these auctions comprise only small, case-specific samples, they suggest auction mechanisms may have the potential to outperform traditional fixed-incentive policies in terms of cost-effectiveness. However, in the case of the Pomona BMP auctions, other factors besides simply cost per tonne of sediment reduction should be considered (e.g., length of time BMP must remain in place).

Future research can shed more light on the cost-effectiveness question using data from additional field and hypothetical experiments. Recall that the Pomona BMP auction incorporated a high degree of simplicity and BMP flexibility per the requests of the local stakeholder group. The bidders responded well to this and proposed many BMPs that reduced sediment loads but did not meet the rigid BMP rules and standards of traditional programs. However, there are obvious tradeoffs that should be considered. For example, on one hand, making an “across the watershed” assumption of a 50 percent decrease in soil erosion from the establishment of terraces might be simple and easy to understand among participants. But, on the other hand, it is evident that inaccuracies will occur at the individual case level. Along the same lines, providing farmers the

¹⁵ These estimates were based on Iowa cropland. Corresponding estimates for Kansas cropland were not found. Given that the Pomona watershed is located in the rolling terrain of eastern Kansas, the authors felt it reasonable to make similar assumptions.

¹⁶ Recall that erosion reduction efficiencies were not necessarily calculated on a case-by-case basis, but rather all terrace re-shaping projects, for example, were assumed to achieve a 25 percent reduction efficiency.

flexibility to submit bids for converting cropland to permanent vegetation without fixed rules and engineering standards could result in short-lived and/or ineffective BMPs compared to traditional programs such as the CRP. The Pomona WRAPS leadership group understood the potential tradeoffs between such things as simplicity versus accuracy and flexibility versus durability; however, they were comfortable with “thinking outside of the box”, putting trust in those who live and work in the watershed, and garnering high participation among the farmers and landowners in the watershed. To those ends, they were successful.

While effectively achieving the goal of high landowner and farmer interest and participation, these “flexible” rules made it difficult to compare cost-effectiveness from a quantitative standpoint. An approach similar to Selman et al. (2008), where BMPs funded via an auction must comply to the same rules and standards of EQIP, would allow for more direct comparisons either across time (as in Selman et al., 2008) or space to traditional conservation programs. For example, one could compare to a control region or county. In this type of analysis, the county which uses a reverse auction to administer all of their EQIP funds in one year could be compared to a neighboring (and similar in most aspects) county that followed status quo EQIP. Research could also be extended to examine alternative auction formats and the tradeoff between auction complexity and effectiveness.

Overall, the BMP auctions provided an excellent opportunity for stakeholders to actively participate in applying scientific information via field scale modeling and economic theory to guide change in the watershed. While these auction projects will not be mistaken for being controlled experiments, they do provide insight into the use and effectiveness of an innovative policy tool. This project also serves as an example of how cooperation and collaboration between University Extension, NRCS, county conservation districts, Army Corps of Engineers, and local watershed stakeholders can yield positive results. The lessons learned from the project can help guide future conservation programs seeking market-based solutions to bring about environmental benefits and researchers interested in analyzing the effectiveness of these mechanisms.

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